LETTERS

Jas. B. Eads

FROM

LEADING ENGINEERS

AND

NAVAL ARCHITECTS

AS TO THE PRACTICABILITY OF CONSTRUCTING AND OPERATING

A SHIP RAILWAY.

ST. LOUIS:
G. I. JONES & COMPANY, PRINTERS.
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SHIP RAILWAY.

The publication of the following letters from the most eminent naval architects, engineers, and professional experts in Great Britain, the United States, and other countries, should suffice to dispose forever of the question of the practicability of constructing a ship railway and of transporting loaded vessels on it across the American Isthmus. They are published as they were written, with the addition of an occasional biographical detail, to further emphasize the value of their testimony.

The very able and unanswerable letter of Sir Edward J. Reed to Admiral Ammen has already been published separately, but it is added to this collection, and will be found at the end of the pamphlet. The attention of the reader is particularly directed to it, as it discusses the subject at full length, and demonstrates in a most convincing manner not only the entire practicability of the ship railway, but its superior economy over every other plan of Isthmian transit.

It will be noted that some of the letters are addressed to Sir Edward Reed. They reached him at the time when he had the important questions submitted to him by Admiral Ammen, under

consideration, and are the result of his interchange of views with the writers.

Nothing could add to the value and completeness of the evidence of these letters with regard to the question at issue. They are written by men of eminence and distinction in their profession, who would never lend the weight of their authority to any doubtful statement, nor risk their reputations in supporting an impracticable project. Their evidence closes finally the question as to whether the ship railway is scientifically practicable. In addition to these letters, the plan has received the sanction of the ablest scientific journals in Europe and America, and I therefore deem it unnecessary to reply to any of the arguments that have been published by others against the practicability and economy of transporting ships across the Isthmus by rail.

Inasmuch as some doubt has been raised as to the practicability of the route by misstatements of the topography of the country along the line, it is only necessary to refer to the letters of Don Francisco de Garay, on page 18; of Mr. E. A. Fuertes, on page 31; and of Mr. J. J. Williams, on page 28, to show the utter unreliability of such statements. All three of these engineers are much more familiar with the Isthmus, through the careful surveys which they have each made for canals and railroads across it, than any other parties assuming to have knowledge of the route of the ship railway. This route has not yet been definitely determined, although my surveys have demonstrated the existence of two different ones, both of which are entirely practicable, and on one of which there are no grades greater than one foot in a hundred, and the distance over which such a grade as this is requisite will not exceed one-tenth of the entire route. It is believed that additional surveys will develop a still better route. James B. Eads.

St. Louis, December, 1881.

The writer of the following letter, Nathaniel Barnaby, C. B., is the present Chief Constructor of the British Navy.

London, October 8, 1881.

Dear Sir: — I was not prompt to offer you a written opinion upon the part of your system of ship railway, to which you told me certain persons had objected, viz., the possible straining of

loaded ships when lifted out of the water, and as a mere consequence of losing the support of the water.

I saw that you had so thoroughly considered the question in all its bearings, that I did not suppose any word of mine could be useful to you.

I learn, however, from Sir Edward Reed, that you think otherwise, and are not willing to leave any obstacles on the road to success, if pains and care on your part can remove them.

I note, therefore, the question you wish to put to me, which is: "Do I think the problem insoluble of constructing a car, on which a fully loaded ship can be safely transported over such a railway as could be built through a tolerably level country?"

In reply to this, I say not only that it is soluble, but that the solution is, in my opinion, fairly indicated in your plans as laid before the Committee on Inter-Oceanic Canals and shown to me.

Ships which would be strained by ordinary docking, would be liable to be strained also when suspended on a car not specially designed for their crazy condition; but such ships would be still more strained in their ordinary sea passages.

I am, dear sir,

Yours faithfully,

NATH'L BARNABY,

Director of Naval Construction.

To MR JAMES B. EADS, St. Louis.

Mr. John, the writer of the following, is a Fellow of the Royal School of Naval Architecture and Engineering; was, until recently, the scientific adviser of the Committee of Lloyd's Register of British Shipping, White Lion Court, Cornhill, London, and is now the manager-in-chief of the Barrow Ship-Building Company, which has just completed the construction of the Inman Steam Liner, the "City of Rome."

The fact that Mr. John was for many years the scientific adviser to the Committee of Lloyd's Register of British Shipping, should not be passed over without an explanation to the popular reader: The Committee of Lloyd's Register of British Shipping publishes what are known as "Lloyd's Rules." These state the different sizes of the various parts of vessels by which they are entitled to be insured as first-class sea-going ships, and unless all vessels are built in accordance with these rules they are refused insurance. The duty of the scientific adviser is to investigate all of the various strains to which vessels are liable in violent storms or when stranded, and to determine, according to the length of the vessel, her breadth and depth, etc., the sizes of the plates or planking, the beams,

ribs, floor timbers, keels, keelsons, etc., that are necessary to safely sustain these strains. The very highest acquirements in the science of ship-building are, therefore, absolutely necessary to fit a naval architect for this highly important position. These rules being published, any intelligent ship-builder, without a knowledge of the scientific principles involved in ship-building, is able to build vessels which would be ranked as A. 1 by the underwriters in England and the United States.

BARROW SHIP-BUILDING COMPANY (Limited),
BARROW-IN-FURNESS, LANCASHIRE, Oct. 6th, 1881.

MY DEAR SIR EDWARD:—

I have, in accordance with your request, carefully thought over the question of the ship railway, and altho' the practical difficulties of carrying it out would be great and will require the most careful foresight and arrangement, and the most accurate calculations, I do not see that the problem is at all an impossible one.

The practice of lifting a ship of large size clean out of the water has become an every-day occurrence. The further step of lifting her to a considerable height is not a great one, especially if you can start with her floating in a considerable depth of water. Beyond these the conveyance of her over a railway, provided the latter is moderately level and moderately straight, is a simple matter which is certainly not outside the reach of civil engineers.

We could unquestionably do the lifting and depositing part of the business, and from an engineering and scientific point of view these must be the greatest difficulties.

I do not enter into the question of cost, because it would involve an investigation of details which I have not at the present moment the time for. I would not, however, hesitate to go into it if it was coming to immediate practical business.

Believe me, yours faithfully,

WM. JOHN.

SIR E. J. REED, K. C. B., M. P., Broadway Chambers, Westminster.

George Fosbury Lyster, Esq., the writer of the following letter, is the engineer-in-chief of the Liverpool Docks, a position which he has held for twenty years. He is recognized as one of the most able and conservative engineers in England. The docks referred to, constructed from the designs of Mr Lyster, are among the wonders of the world. The Alex-

andra Docks, opened by H. R. H., the Prince of Wales, on the 8th of September last, required seven years in their construction, and involved an expenditure of twenty-five million dollars. Either one of two of the Alexandra Docks is capable of docking the "Great Eastern":—

MERSEY DOCK ESTATE.
ENGINEER'S OFFICE, DOCK YARD,
LIVERPOOL, 2d November, 1881.

DEAR MR. EADS:—

In reply to your letter of the 16th ult., referring to the several interviews I have had with you during your recent visit to this country, on the interesting subject of your proposed ship railway across the Isthmus of Tehuantepec, as also to the papers which you were good enough to leave with me, further illustrating your opinions on the point, I have now been able to give the whole matter, as far as its engineering features are concerned, very careful consideration, and have concluded that if the permanent way, cradle arrangements, and general details are carried out in the ingenious and substantial manner you described, there will, in my judgment, be little or no difficulty in transporting properly constructed ships from sea to sea with entire convenience and safety.

As regards the advantages of the geographical position selected by you for the undertaking — not having visited the locality, I, of course, am unable to give an opinion of any value on the point; but from the views you laid before me, and the reasons you urge for its adoption, it appears to me that your arguments are unanswerable and worthy of support.

Wishing you every success towards the fulfillment of this grand conception, I remain. Yours very faithfully,

GEORGE FOSBURY LYSTER,
C. E., and Mem. Inst. C. E., Engineer-in-Chief, Liverpool Docks.

JAMES B. EADS, ESQ.,
502 Chamber of Commerce, St. Louis, U. S. A.

Mr. John Fowler, the writer of the following letter, was consulting engineer of the Egyptian Government, engineer-in-chief of the Metropolitan (Underground) Railway of London, and is now constructing by far the largest bridge in the world. He is a past president of the Institute of Engineers in England, and a gentleman who is recognized as one of the ablest and most experienced of living engineers: —

2 QUEEN SQUARE PLACE, WESTMINSTER, September 4, 1881.

My Dear Sir: — You will be interested to know that about

eight years ago, when acting as consulting engineer to the Egyptian Porte, I was instructed to prepare a project for the transport of steamers and other vessels from one level to the other at the First Cataract of the Nile.

After a very careful investigation of the alternative plans of canal and ship railway on the spot, I decided in favor of the railway, having satisfied myself that there was no mechanical difficulty in carrying ships of any size, without injury to themselves, on a properly designed car or cradle over a solidly constructed railway. Yours very truly,

JOHN FOWLER.

CAPT. JAMES B. EADS.

The distinguished writer of the following letter, Mr. E. Leader Williams, was the chief engineer of the Trent and Mersey Canal, and was the originator of the celebrated Anderton Lift, which unites the River Weaver with the canal by means of an ingenious arrangement by which a section of the canal, about 150 feet long and containing two barges and the water in which they float, weighing in all about 250 tons, is raised and lowered by simple hydraulic apparatus through the space of fifty feet.

This lift has been in operation for seven years without the slightest accident, and has given such satisfaction that the government of France has ordered one of four times its capacity to connect two different levels of one of the French canals, and the government of Belgium is now building four similar ones of still greater capacity: —

QUEEN'S CHAMBERS, JOHN DALTON ST.,
MANCHESTER, September 5, 1881.

Dear Sir: — I consider your plan for a ship railway quite practicable, and that it may be developed into a sound commercial enterprise.

When I first proposed to lift loaded boats vertically fifty feet, so as to pass them in three minutes from the River Weaver to the Trent and Mersey Canal without locks, many persons considered my scheme visionary. You, however, have seen the lift at work, and it has now been in constant operation, without any hitch, for the past seven years.

I believe that your ship railway only requires carrying out into execution to prove most successful in every way.

Yours very truly,

E. LEADER WILLIAMS,
M. Inst. C. E.

JAMES B. EADS, ESQ.

The following letter is from the engineer now in charge of the Anderton Lift:—

WEAVER NAVIGATION, ENGINEER'S OFFICE,
NORTHWICH, ENGLAND, October 20th, 1881.

My Dear Sir:— Having been for five years employed in superintending and carrying out works of various descriptions in shipbuilding yards, including the construction of ships of large size, and the repair of ships on hauling up slips, and having for the last four years had charge of the Anderton Lift on this navigation, which is used daily for raising laden barges a height of fifty feet to transfer them to a canal on the upper level, I am satisfied that the proposal of Captain Eads to raise ships by mechanical means and convey them overland on a railway and on carriages especially designed for the purpose, is one which is feasible and ought to succeed; and that the strains on the hull may be more accurately calculated and provided for on land than is possible when ships are subject to the varying conditions inseparable from a sea passage in stormy weather.

I remain,
Yours faithfully,
LIONEL B. WELLS,
M. Inst. C. E.

SIR E. J. REED, K. C. B., F. R. S., M. P.

Mr. Duer, the writer of the following letter, is an able civil engineer, who has devoted many years of his life to the study of hydraulic apparatus for lifting vessels: —

6 WESTMINSTER CHAMBERS,
VICTORIA STREET, LONDON, September 2, 1881.

CAPTAIN EADS, ETC., ETC.

Dear Sir: — Previous to the day on which I had the pleasure of meeting you at Anderton, and of there explaining to you the details of the canal-lift, a ship railway was a subject to which I had never given serious attention, and for want of proper examination my prejudices were not favorable to it. Since that time I have, however, given a considerable amount of thought to this subject, and as I have for many years been in the habit of seeing ships standing out of the water on floating pontoons, and moved about in all kinds of weather at the Victoria Docks, my mind

could easily pass to the consideration of a ship similarly mounted on a carriage on land; and when it is remembered that the ships at the Victoria and other hydraulic docks remain on the pontoons for days and weeks together, sometimes with their cargoes on board, I feel that there ought to be no doubt as to the safety of a ship at rest on a properly constructed carriage.

As all the details of the large hydraulic dock which was constructed ten years ago for the government of Bombay, were entrusted to my care, and as this dock is capable of lifting any ship afloat, my experience fully justifies me in saying that the largest ship can be as readily and safely placed on a carriage as a small one can.

When, again, I reflect on the nature of the strains to which a ship is subject at sea: the shocks that occur from the blows of heavy seas, and the large portions of the ship's surface that are at times entirely out of the water, I begin to wonder why any one should doubt that it would be as safe or even safer on a well-constructed railway than when so tossed and buffeted about in what we have hitherto regarded as its proper element. As I am not acquainted with railway traveling in America, I must call to your remembrance the ease and comfort with which one journeys on the London and Northwestern Railway of England. It is not difficult on this railway to forget altogether that one is traveling, while in a gale at sea this oblivion is impossible.

As a ship is ordinarily supported in a graving-dock on keel blocks with side shores placed on the altars, as the level of the water in the dock falls, it must be considerably strained, as almost the whole of its weight is carried on the keel; but when the bilge-blocks are carefully introduced under water while the ship is afloat it must be almost, if not quite, as free from strain as when in smooth water. To avoid all danger from too much weight being carried on the keel, the bilge-blocks for the Bombay Dock were so designed that the ship on a pontoon can, if desired, be lifted entirely off its keel and the whole of its weight carried on the bilges. With a system of blocking so entirely under control it is impossible that a ship can be injured while on a good carriage on a good railway, as the deck-beams must be amply sufficient to resist any outward thrust that can arise from the cargo. In a word, we may say, from long experience, that there is no danger or difficulty in placing a loaded ship on a carriage suitable for a railway, of trans-

porting that ship and carriage from the water to the railway; and when this is done, I am of opinion that it will not be difficult to draw it quickly and safely across the Isthmus.

These and other considerations too numerous to trouble you with in a letter which has already become too long, have converted me from being skeptical to having perfect confidence in the railway you propose, and I hope that you may be enabled to carry out your project which, while being perfectly practicable, so far exceeds in grandeur anything that man has yet attempted.

I am, dear sir,

Yours faithfully,

SIDENGHAM DUER.

The following letter is from the distinguished civil engineers, Clark & Standfield, who have had a most extensive and successful experience in lifting ships. Mr. Edwin Clark was the chief assistant of Robert Stephenson in the building of the celebrated tubular bridge over the Menai Straits, and is the engineer who introduced the hydraulic vertical lift system, the most notable example of this kind being at Bombay; another, of lesser capacity, at Malta; and still another at the Victoria Docks, in London, all of which works have given the most perfect satisfaction:—

6 WESTMINSTER CHAMBERS,
LONDON, September 6, 1881.

CAPT. J. B. EADS, C. E.

Dear Sir: — Referring to our interview on the subject of the proposed ship railway across the American Isthmus, we now beg to say that our works are likely to be so much occupied during the next year that we should scarcely be in a position to execute any works out of England in connection with the proposed railway, but we should be very happy to prepare the drawings for the construction of the terminal works for lifting the vessels at the Atlantic and Pacific ports.

We understand it will be requisite to transport loaded vessels of the weight of 4,000 to 6,000 tons, more or less, on the railway at the rate of about six miles per hour, on a gradient of one or two per cent, and that it will be required to raise the vessels on a railway car out of the water to a variable height not exceeding 46 feet, and deposit them on the rails in a time not exceeding thirty minutes. These conditions may be fulfilled in two different ways, and we need not say that it is a plan in which Mr. Edwin Clark

has entire confidence, and in which he will take the fullest interest in arranging the details. The hydraulic system would probably be the most rapid but probably the more costly. At the Bombay Hydraulic Dock we have lifted weights up to 12,000 tons, with 72 presses, 14 inches diameter, and 36 feet stroke. The Victoria and Malta Hydraulic Docks have been many years in constant operation.

At the canal lift at Fontinettes we employ presses with rams, 6 feet 7 inches in diameter, with a 50-feet stroke. Each of these presses will raise a dead weight of 1,000 tons through a height of about 50 feet, in three minutes. The weight lifted is a movable portion of the canal, about 132 feet long, containing the water and a barge floating in it. This work is now in course of construction for the French government, and it is to be erected near St. Omer, in France, and we are now designing a set of four similar canal lifts for the Belgian government, in which the weight raised will be somewhat larger. It is evident that a few presses such as these would more than accomplish the work required.

Our ordinary depositing dock, similar to that at Sebastopol, which raises vessels of 6,000 tons, would also meet the requirements of the case very satisfactorily. We are now constructing a second of these docks, of 10,000 tons, for the Russian government at Vladivostok, and a third, of 3,000 tons, for the Barrow and Railway Company, at Barrow-in-Furness, to be afterwards increased to 5,000 tons. We have designed one of these docks for the Italian government, to raise iron-clads of 15,000 tons' weight with a lift of 30 feet. There would be no difficulty in modifying the proportions so as to render it suitable for a lift of 46 feet, and this form of dock raises the vessels out of the water and deposits them on a gridiron stage in a most convenient manner for railway transport.

It will probably depend to a great extent on their relative cost as to which of these systems may be adopted, and we shall be prepared at any time to go into the necessary calculations, and render every assistance in our power towards the accomplishment of the great work in which you are engaged.

We apprehend no difficulty in perfecting the necessary details of the plans so as to insure the safe transportation of the largest loaded ships on the railway cars with absolute safety.

We remain, dear sir, yours faithfully,

CLARK & STANDFIELD.

The writers of the following letter are the contracting engineers who constructed the Anderton Lift and the hydraulic docks at Malta and at Bombay. The execution of these works was so satisfactory as to prompt the most flattering testimonials in their behalf: —

HEATON FOUNDRY, STOCKPORT, October 1, 1881.

JAMES B. EADS, ESQ., C. E.

My Dear Sir: —When you are ready to commence the construction of your ship railway, we shall be pleased to undertake the building and completion of the necessary works for placing the ship, with her cargo, on the railway track, ready for attaching the locomotives to her, and after transport across the Isthmus to lower her safely again until she is afloat. A lifting apparatus will be required at each side of the Isthmus which will lift or lower ships as required. This portion of the work we are fully prepared to execute with the greatest promptness, on the same terms on which we built the hydraulic docks at Bombay and Malta, and the Anderton Canal Lift in Cheshire.

We have no hesitation in guaranteeing the lifting of a fully loaded ship or steamer of 8,000 or 10,000 tons' weight on a railway car from the sea or harbor level to that of your permanent way in 30 minutes, with absolute safety to the ship and the works where the lift is not over 50 feet vertically. We will undertake to construct all the plans and works necessary to do this at each end of your line, and complete everything ready for attaching the locomotive to the car on which the ship is to be lifted and transported; this car, or any number of them, we will furnish also.

The locomotives and railway construction are not in our line; but if it were a matter of importance to cover, in addition, the construction of the locomotives, turn-tables, etc., and ten miles of railway, as proposed by you to the United States, we have no doubt we could unite with us some other responsible parties engaged in that kind of works, to execute them and guarantee the safe transportation of the loaded ships of the weight mentioned, over the railway. Very truly yours,

EMMERSON, MURGATROYD & CO.

The following letter is from W. Pearce, Esq., who is the sole proprietor of John Elder & Company's works, Govan, Glasgow. These works are so celebrated that it is only necessary to say that a great many

of the finest and largest steamers trading between New York and Great Britain were constructed in them:—

FAIRFIELD WORKS,
GOVAN, NEAR GLASGOW, 26th August, 1881.

MY DEAR SIR EDWARD: —

In replying to the letter enclosed in your note to me of the 17th inst., I would observe that the constant use of iron floating docks proves that the largest ships, including heavy armour clads, may be lifted out of the water without any damage, and also that loaded ships may be lifted upon the same conditions as if they were put into a graving-dock loaded.

I am of opinion, from what I know of the working of iron floating docks that I have designed and built, that iron steamers of 4,000 to 5,000 tons' displacement may be docked, loaded, without any injury whatever.

It is also my opinion that a ship railway for vessels of this size may be constructed and worked successfully, provided the land is solid and the line moderately level.

I remain, my dear Sir Edward,

Yours faithfully,

WM. PEARCE.

SIR E. J. REED, K. C. B., M. P.

The writer of the following letter, Mr. B. Baker, is the partner of Mr. John Fowler, C. E., and is recognized as one of the ablest engineers in London: —

2 QUEEN SQUARE PLACE,
WESTMINSTER, September 13, 1881.

DEAR CAPTAIN EADS: —

As you are aware, I have during the past twenty years had occasion to consider, in conjunction with Mr. Fowler, many novel problems, and amongst them the transport of laden vessels by rail and by pontoon. One project elaborated by us was a ship-incline at the First Cataract of the Nile, and another was a ship-canal from Alexandria, through Cairo, to Suez. The latter project involved the elevation of the largest ocean steamships high and dry on shallow pontoons for the purpose of passing them across the Nile at low summer level. Political jealousies alone have

delayed the execution of this work. English and French capitalists are still prepared to find the required £10,000,000, and shipowners to entrust their laden vessels to the pontoons.

Whether a ship be placed on a railway car or on a pontoon will obviously not affect the question of the safety of her being lifted high and dry when fully laden. When critics have expressed to me their opinion that a ship would be injured by so doing, I have invited them to condescend to a little more detail, and to point out which bottom plate would be bulged, which frame bent, which butt-joint opened, and why? The general laws affecting the strength of materials apply to iron and steel ships as to other metallic structures, and in order to show that any of the above injuries could result, I have satisfied myself, by long and careful investigation, it is first necessary to assume either criminal negligence or a singularly badly designed car. In other words, apart from all practical experience in dry docks and elsewhere, it can be theoretically demonstrated that a vessel which would not break up at sea in an ordinary gale, would not be injured by transport in a well-constructed car, on a suitably formed railway.

With reference to the latter point I am prepared to admit that a railway which may be all that could be desired for the high-speed transit of an articulated railway train, is not necessarily suitably formed for the transport, at comparatively low speeds, of a long, rigid car and ship. Elasticity is one of the chief desiderata in the first case, while perfect immobility is the most important in the second. In rock cuttings perfect immobility is clearly at once attainable, by simply laying the steel rails direct on the rock and holding them down by spikes driven into oak trenails fixed in holes drilled in the rock. This may, perhaps, appear a bold and novel experiment to some engineers, but it is nothing of the sort. About thirty-five years ago a portion of the Leeds and Manchester Railway was so laid, the cast-iron chairs being spiked directly to the rock: and the system, though necessarily too hard and rigid for fast trains, proved quite satisfactory for slow-speed traffic. In ordinary cuttings through soft soil, immobility would, in my opinion, be best attained by reverting to the old plan of stone block sleepers, and bedding them in a continuous foundation of concrete laid under each rail. In the case of embankments, special precautions would be required to attain immobility. I understand that the banks will be formed of the material taken from the rock cuttings.

and nothing better for the purpose could be desired. It is necessary, however, to remember that the voids in a rubble bank constitute about thirty to forty per cent of the whole contents, and that such banks are liable for some years to considerable and unequal settlement, unless these voids are previously filled with smaller materials. At Alderney Breakwater, for instance, although the rubble mound was allowed three years to settle before the masonry superstructure was commenced, the latter sunk about six feet into the mound, in places. In my own practice, I have found that all settlement is obviated if a proper proportion of sand and gravel or quarry rid be tipped with the rubble, and the bank be watered liberally as it is brought up. If you adopt this plan, and take the additional precaution of running a twenty-ton steam road roller a few times along the line of each rail-bed previous to putting on the concrete foundation for the stone block sleepers, you will, I have no doubt, attain as perfect immobility on the banks as elsewhere.

It will be self-evident to most persons that ship-owners would much prefer to entrust their ships to a special roadway, as true and inflexible as a lathe-bed, than to an ordinary elastic railway, the truth of which would be dependent upon the care bestowed by the plate-layers in packing the sleepers. The saving in maintenance is also self-evident, for with good 80 pound steel rails spiked to 2 feet square by 1 foot thick stone sleepers bedded upon a continuous layer of Portland cement concrete 2 feet 6 inches wide by 1 foot thick, the road should not require touching for ten years. Some engineers may doubt the propriety of dispensing with the elastic timber sleepers and bedding the rails direct on stone and concrete, therefore it may be well to say a few words on that point.

Firstly, I would quote the following opinion of Stephenson, expressed at the Inst. of C. E. long ago, at the time when about one-half of the railways in this country were laid with stone blocks and the other half with wooden sleepers: "Stone blocks suffice for a railway for the conveyance of heavy minerals at a speed of about twelve miles an hour;" indeed, he thought "a stone block road offered less resistance than a timber sleeper road, and with these slow trains resistance is a very important object."

Again, I would draw attention to the fact that the result of our experience with tramways, subject to the enormous wear and tear

of London traffic, is the adoption of a deep-flanged rail bedded direct upon a solid concrete foundation without the interposition of any elastic medium.

Finally, I would mention that about three years ago stone blocks were re-introduced on a heavily worked mineral line in Cornwall with entire success and with the cordial approval of the government inspectors. The cost of maintenance has proved to be light, and it is found that with the modern type of foot rail properly fished, the fastenings no longer work loose as in the old block roads, and the railway, for all practical purposes, is as noiseless as the best maintained timber sleeper lines.

I have explained at some length what I understand by the term a suitably formed railway, because I am of the opinion that the success of your novel and difficult undertaking will depend upon attention to details. I am further of opinion that ship-owners are entitled to demand that the ship railway shall be something far more solid and immobile than an ordinary railway, even though the weight upon the car wheels be no more than usual. With this principle admitted, the public, I feel sure, will have full confidence in your ability to carry your project to a successful conclusion.

Yours faithfully,

B. Baker.

Captain Eads.

Mr. Francis Elgar, the writer of the following letter, is a Fellow of the Royal School of Naval Architecture, and was until recently general manager of Earle's Ship-building and Engineering Co., and is a naval architect of recognized abilities: —

Broadway Chambers, Westminster,
London, S. W., 29th August, 1881.

My Dear Sir: I have carefully considered the letter from Capt. J. B. Eads, of which you sent me a copy, respecting the practicability of raising loaded vessels out of the water, and transporting them by railway over a tolerably level country with safety.

1. As to raising a fully loaded ship out of the water: It is surely practicable to arrange for doing this without risk of injury to a well-built ship. Vessels more or less fully laden have been occasionally docked in a dry dock in this country in emergencies.

and more frequently abroad; and they have also been lifted out of the water by hydraulic appliances such as the hydraulic dock at Malta. Ships of war, with bottoms much weaker and less adapted for enduring the strains of docking than ordinary merchant vessels, have also been docked with all their principal weights, such as armor, guns, stores, etc., on board. When one sees the rough way in which iron steamers are sometimes docked and slipped without injury when light, but with engines and boilers on board, and the small amount of support they get during the process, there can be little question of their being able to stand the strain of docking or lifting out of the water with a full cargo, if means are devised for doing it by which the bottoms and bilges and some portions of the sides will be well supported.

2. As to transporting a loaded vessel by railway over a tolerably level country, I see no reason to prevent rails being laid and a cradle constructed to run upon it that will carry a loaded ship at a moderate speed through the country without risk of injury. The cradle will require to be arranged so that the bottom of the ship shall receive continuous support over as much of its surface as possible, and it should be practicable to do this so that any straining caused by this railway transport will not exceed that met with by ships under the other conditions of their employment.

I am, dear sir,

Yours very faithfully,

FRAN. ELGAR.

SIR E. J. REED, K. C. B., M. P.

Don Francisco de Garay, the writer of the following, has been made a member of the Legion of Honor by the French government as a recognition of his eminent abilities as a civil engineer. He is at present engineer of the Valley of Mexico, and was sent by the Mexican government to the canal convention at Paris in 1879.

MEXICO, September 22, 1881.

Dear Sir: — I have been greatly surprised to read in a newspaper that Captain Phelps had stated that Mr. McAlpine had informed him that "your engineer" had selected a route for the ship railway which involved a cutting in one place 800 feet deep. As I am the engineer referred to, I feel myself bound to rectify

this gross error, without being able to understand how such a great mistake has been made.

By the profile of my line (of which you have a copy) it can be seen that the deepest cutting exists at Banco Marques, on the western slope of the hills that line it on that side the Pass of Chivela. That cut is 312 feet maximum depth, but the ridge that it divides has only 2,500 feet in thickness.

I have felt also some surprise at reading Mr. McAlpine's letter to Admiral Ammen, dated June 3rd. I have not the pretension to refute Mr. McAlpine's criticisms, but I must give some explanations about the location of the railway line that I made in the Isthmus. That line for the present is only a study; it may be modified, but on the whole I think that it is in the right place. It comprises the most difficult part of the route. It has been traced with the transit and the level right across the mountain ridges by the Chivela Pass, in a single straight line, from the suberb of San Blas, near Tehuantepec, to the borders of the Chichihua River, in a distance of 40 miles. The country is very rough, but owing to the geological formation of the soil, the work of excavation and filling will be easy. The dividing ridge between the two oceans in the Isthmus runs east and west. The nucleus of the range is formed of blue limestone, covered by a formation of shale that has been upheaved, and which constitutes the lower parallel hill ranges, with very steep slopes.

The line which I have run cuts all the ranges almost perpendicularly, forming numerous peaks, very difficult of access for the engineer, but most convenient for blasting, as well as for the solid establishment and drainage of the way. In all the distance surveyed by me, from the Chichihua to Tehuantepec, there is no change of line. In Tehuantepec, or near it, there must be a turntable to direct the railway to the Bay of Salina Cruz, or to the Upper Lagoon. I must here observe that I have never proposed to carry the railway across the coast range to Shipehua Bay. On the contrary, on my return to Tehuantepec from the Pacific coast, I gave it as my opinion to Mr. McAlpine (on being asked by him), that no railway could be conveniently carried across the Sierra Alta range, and that the best and only way to reach Shipehua was by Salina Cruz, and thence following the coast, tunneling through all the promontories that divide the bays. With a ship railway even that line is impossible.

Now with regard to grades: I have no grade on my line above two per cent, and for no greater distance than two and a half miles. The ascent to the summit, as well as the descent, are constant, but divided in different short sections.

To resume what we have said, we see:—

1st. That the line traced and located by our commission for the present is only a study, that may be improved and perhaps even abandoned for a better line, if, in subsequent surveys, more favorable ground is found.

2d. That such, as it has been traced and located, the line from the Pacific to the Chichihua River, has only one break in a distance of fifty miles.

3rd. That in all the line there is no grade greater than two per cent, and in no greater distance than two and a half miles.

4th. That the greatest cutting is 312 feet in maximum depth, and 2,500 feet in length.

5th. And finally, that the results obtained have demonstrated the entire practicability of the ship railway, which was the main object for which the commission was sent to the Isthmus. I have no doubt that you will be able to answer the objections that Mr. McAlpine makes to your plans. For my part, I am quite satisfied with his final declaration, as he admits the whole question in his statement that the ships cannot be carried at a greater speed than one mile an hour over the railway. This would be only six days from sea to sea, by the route of Tehuantepec, and would even then be a saving of time and distance between the east and west coast of North America over any other line by Nicaragua or Panama. Besides, we must not forget that when the Liverpool and Manchester road was opened, a speed of six miles an hour was considered almost impossible; to-day, on the same railway, the trains run sixty miles an hour. If we begin with one mile on the ship railway, before long we will run ten or fifteen.

Although most of the data put in this letter were already known to you, I have thought it proper to set them again before your eyes, hoping that they may be of use to you.

Yours very truly,

FRANCISCO DE GARAY.

TO JAMES B. EADS.

The writer of the following, William Sooy Smith, is an American

engineer of great experience and ability. He designed and constructed some of the most important railroads and bridges in the United States, and he is now in charge of the tunnel under the Hudson River, which was placed in his care after the occurrence of the frightful accident at that work in 1880: —

NEW YORK, July 15, 1881.

CAPTAIN JAMES B. EADS.

Dear Sir: — As part of the designs of a canal around Niagara Falls on the American side, which I made in the year 1857, I planned a ship railroad to carry vessels navigating the Western lakes down the side of what is called the mountain, near Lewiston.

The study given to the subject at that time convinced me of the entire practicability of moving ships of the largest size over land safely, expeditiously, and economically. This conviction has been strengthened by all the investigations and observations made upon the subject ever since.

I was told by learned Greeks in Athens that their countrymen built and used a ship railway to transfer ships across the Isthmus of Corinth long before the Christian era.

Ship railways on a small scale have long been in successful operation, both in this country and Europe, and anyone who has seen the large ocean steamers now in use launched, cannot fail to pass by an easy transmission from the very cheap and temporary "ways" which carry them so easily into the water, to a well-constructed railway with a suitable number of firmly-built tracks, over which these steamers with their cargoes can be hauled rapidly and safely.

I should be sorry to doubt that the mechanical skill of our country will prove equal to the task of planning and building such a road, and all the necessary appurtenances, in the way of cradles, to carry ships of the largest size, and traction engines to haul them. This will be but the larger development of a system which is already in successful operation — and such larger development the needs of the present demand.

I believe you can work it out, and I think you have selected the best possible place in which to prove it both practicable and profitable. You have my best wishes for the success of your great ship railway. Very truly yours,

WILLIAM SOOY SMITH.

The following is from one of the oldest and ablest constructors in the United States Navy: —

Orange, New Jersey, January 22, 1881.

Mr. James B. Eads.

Dear Sir: — I have watched with great interest the efforts you are making to establish communication between the Gulf of Mexico and the Pacific Ocean for sea-going vessels by means of a ship railway. In this effort I hope you will have success. With a substantial road-bed for your railway, on the easy grades across Tehuantepec, which, I understand, do not exceed one or two feet in the hundred, there can be no mechanical difficulty in the way of transporting loaded ships by railroad with entire safety to the vessel, whether they be built of wood or iron. With a sufficient number of rails on the road-bed, and a sufficient number of wheels to distribute the weight in the manner proposed by you, the transportation of a fully loaded vessel without straining her hull will be assured. The speed with which you can move the vessel will depend entirely upon the size and number of your locomotives. What weight and power they should possess to move the largest vessels used in commerce at a speed of ten miles an hour, over your maximum grades, is a matter which experienced railroad engineers will be able to determine with great accuracy.

The ship railway plan possesses the advantage of more rapid transit for the vessels, and its capacity could easily be increased to meet the future wants of commerce.

Very truly yours,

Edward Hartt,
United States Naval Constructor.

The following is from another United States naval constructor, of recognized ability and talent:—

Philadelphia, February 7, 1881.

James B. Eads, Esq., Washington, D. C.

Dear Sir: — Having carefully examined the plans and papers pertaining to your proposed ship railway across the Isthmus of Tehuantepec, I do not hesitate to say that in my judgment there

will be no difficulty whatever in transporting, in the manner you propose, any properly built vessel with absolute safety.

Your railway will possess one quite important advantage over the ordinary canal, and that is, that the vessel's bottom, propellor, etc., can be examined, and, if necessary, cleaned in transit, and repairs of whatsoever nature can be made wherever it is practicable to construct suitable sidings, transfer-tables, shops, etc., more economically, other things being equal, than in a dry-dock.

Your well-known skill as a scientific and practical engineer is a sufficient guarantee that this great undertaking will receive careful consideration in every detail, and that it will be a success, both as an engineering achievement and a financial investment.

Wishing you all the success possible, I remain

Your obedient servant,

H. L. Fernald,

Naval Constructor, U. S. N.

The following is from the distinguished engineer who is President of the Mississippi River Commission:—

New York, January 21, 1881.

James B. Eads, Esq., Washington, D. C.

Dear Sir: — I have to acknowledge the receipt of your note of the 17th instant, relating to your project of a ship railway across the Isthmus of Tehuantepec.

In my judgment the construction of a ship railway across the Mexican Isthmus, in general accordance with your plan, is not only feasible as an engineering problem, but the successful maintenance and operation of such a road is entirely practicable as a business enterprise. This assumes that your engineers will find a route of suitable alignment and grades, a question of prompt and easy solution, upon which your information is much greater and better than mine.

In pushing forward this great project, I wish you that full measure of complete success which your will, energy, and prestige as an engineer are so well calculated to command.

Very respectfully, your obedient servant,

Q. A. Gilmore,

Lieut.-Col. Engineers, Brevet Major-Gen.

The following is a letter written by Mr. Henry Flad, a distinguished civil engineer, President of the Board of Public Works in St. Louis: —

To E. W. Fox, Esq., Publisher *Exporter and Importer*, St. Louis, Mo.

Dear Sir: — In reply to your request that I give my views in regard to the ship railroad proposed by Captain James B. Eads, I beg to state my opinions: —

First. That the first cost of the construction of a ship railroad will not be one-fourth of that of a ship canal.

Second. That a ship railroad can be constructed in probably one-third of the time required to construct a canal.

Third. That ships can be transported on such a railroad with absolute safety, and with the same dispatch as through a canal.

Fourth. That the cost of maintenance will be less for a railroad than for the canal.

Fifth. That although the cost of transferring ships by railroad will exceed that of passing them through a canal, the difference will be insignificant compared with the saving of interest on the first cost.

Sixth. That the ship railroad will, therefore, offer a safer and better investment for capital. Very respectfully,

HENRY FLAD, *C. E.*

Mr. O. Chanute, the accomplished and experienced civil engineer, who is superintendent of the Erie Railway, says in a letter to me: —

"I am much pleased to find in this morning's *Tribune* your very able and clear presentation for a scheme for a marine railway across the Isthmus; the rather as I gave some attention to the subject myself nearly a year ago, and reached conclusions almost identical with yours, as to the feasibility and general features of the project. * * * I see no reason why the railway should not be worked at ten miles per hour, and assuming it to be sixty miles long, why a steamer can not be transferred from ocean to ocean in twelve hours."

The following is a letter addressed to me by Commodore R. W. Shufeldt, U. S. N., the accomplished officer who surveyed the Isthmus of Tehuantepec: —

WASHINGTON. D. C., January 21st.

MR. JAMES B. EADS, Washington, D. C.

Dear Sir: — I forward to you with great pleasure, an extract of

a letter from Commodore Farquhar, commanding United States ship "Quinnebaug," at present at Alexandria, Egypt.

* * * * * * *

"I am of the opinion that Tehuantepec possesses the best route for transit. I do not see why a railroad capable of carrying a ship could not be built, and why the long slopes of our route should not be best. The fact of a harbor twenty-five miles long, on the Atlantic side, is of the utmost importance, more so than the one on the Pacific shore, because that is almost always a weather shore in that latitude."

I send you the extract as a disinterested opinion of an accomplished naval officer, not only as to the advantages of the route of Tehuantepec, but as to the practicability of a ship railway across the Isthmus. Very truly yours,

R. W. Shufeldt, *U. S. N.*

The well-known and able civil engineer, Colonel C. Shaler Smith, in a letter last year, said of the ship railway, to the editor of the *Exporter and Importer:* —

The engineering problems involved have all been solved on a smaller scale in the construction of various works in this country and in Europe during the past thirty years, and the adaptation of these tried and proved principles of mechanical design to the case in hand is by no means difficult.

* * * * * * *

It will be a serious reflection on the enterprise of American capitalists, the science of American engineers, and the patriotism of our statesmen, if foreign capital and foreign skill are to perform the work of severing our continents, and then pocketing the profits of an enterprise most of the cost of which must eventually be paid by our citizens in the shape of tolls upon our bi-oceanic coasting trade.

The following is from a member of the Mississippi River Commission, formerly State Engineer of Louisiana, and an engineer of acknowledged ability: —

New Orleans, February 9, 1881.

Dear Captain: — Your letter of February 3rd, in answer to mine, is just received after "accidents by flood and field." The most

terrific gales on record have destroyed many miles of our Eastern railroad connections. I wish we had as stable a transit as your inter-oceanic railway project promises to give. I have followed carefully the development of the designs of this enterprise with increasing confidence in their practicability and correctness. It seems to me to have the great merits of excluding the necessarily uncertain elements in the estimate for any canal; of relying upon the experience of successful engineering works differing from this only in magnitude; of avoiding a direct and dangerous conflict with natural obstacles, such as the damming or diversion of water-courses, the control of floods, etc.; of latitude in choice of location resulting in stability and economy; of facility and rapidity of construction, maintenance, and repair, and of an easy extension of capacity proportioned to an increased trade. These points, together with its extremely favorable geographical location, give the ship railway, in my judgment, a decided advantage over other plans for Isthmus transit. I shall impatiently wait for the first through train. Very truly,

B. M. Harrod.

The following is from Mr. T. C. Clarke, of the firm of Clarke, Reeves & Co., one of the most able and successful railroad and bridge engineers in the United States:—

"I am desirous that my opinion should be put on record that your ship railway is practicable to construct, and can be maintained as easily as any other railway having as large a tonnage; and that vessels of four thousand tons can be carried across without injury to themselves or their cargoes."

The following is from Gen. G. T. Beauregard, formerly a member of the United States Corps of Engineers:—

New Orleans, January 25, 1881.

My Dear Sir: — I take pleasure in communicating to you, in as few words as possible, my views relative to the practicability and economy of a ship railway across the Isthmus of Tehuantepec. I feel no hesitancy in saying that I see no difficulty in constructing a railway strong enough to carry out the object referred to. It is only a question of the strength of the cradle to hold the ship,

and the division of weight on a sufficient number of rails and wheels, which can certainly be accomplished by any engineer of ability and ingenuity.

As to the danger a loaded ship would incur in being transported on a smooth and well-built railway, it is all imaginary, for it would be well braced and cushioned in a strong car or platform, supported by spiral steel springs on a very large number of wheels which, being separate from each other, could be easily replaced if broken during the trip. Moreover, the breaking of one or a few of them out of so many would not endanger the rest.

With regard to the economy of such a ship railway, I would remark that the tonnage carried over it being moved entirely by machinery, and the ratio of paying cargo to dead weight being much greater than on ordinary railroads, the cost of operating such a railway must be much less. The cost of maintenance should be also less in proportion, for the road would be substantially built and short in comparison to the amount of tonnage carried over it. Moreover, the machinery used would be simple and substantially made. It is, therefore, safe to assume that the current expenses and those of maintenance would not exceed fifty per cent of the gross receipts, which would be more profitable than from a canal costing probably two or three times more than a ship railway, and requiring three or four times longer to build, thereby increasing greatly the amount of interest alone on the actual cost of the canal.

A ship railway has other important advantages over a canal, such as the facility with which the number of trucks could be increased to accommodate the demands of commerce; the rapidity of transit and the greater number of vessels per day that could be transported than through a canal; the practicability of building a railway where a canal would be impossible; the ability of estimating correctly for the first, while the latter, if partially built under the water, or liable to be submerged or interrupted by water, would be very difficult, if not impossible, to be estimated for as to cost and time of completion. I am, yours very truly,

G. T. Beauregard.

Mr. J. J. Williams, a very able engineer, with long experience in rail-

road building, who has made a number of surveys for railroads on the Isthmus of Tehuantepec, says: —

"I have been greatly interested in your proposition to construct a ship railway across the Isthmus of Tehuantepec for the largest class of merchant vessels. Having carefully examined the details of your plans for accomplishing the object, and being thoroughly familiar with the topography of the Isthmus, I desire to express my full conviction of their entire practicability."

Mr. E. L. Corthell, the engineer of the bridge across the Mississippi River at Louisiana, and of the Sny Island Improvement Works, and who was resident engineer at the jetties until their completion, writes as follows:

"My studies of the engineering difficulties convince me that they can be easily overcome, and I believe the ship railway for the transportation overland of the largest vessels can be made entirely successful, and that ships can be transported more rapidly by the railway than by the canal, and with equal safety."

The following is from one of the engineers sent by the United States to Europe to investigate the improvement of the mouths of rivers there, and to report upon the jetty system. He is likewise an experienced railroad engineer: —

Richmond, February 5, 1881.

James B. Eads, Esq.

My Dear Sir: — Why should not your ship railway be practicable? Ships have been hauled on marine railways for I know not how many years, and the hauling of larger ships a longer distance is only a development or expansion of this practice, as the steel roadway worked by locomotives is the development of the tramway, or the old incline worked by stationary power.

The idea is worthy of the age, and to make it a success you have simply to improve and expand the details of the old marine railway and make it more perfect. I have the greatest confidence in your ability in this particular, and hope you will have the opportunity to demonstrate it. Very truly yours,

H. D. Whitcomb,

Civil Engineer in Charge of Improvement of James River.

The following is from the accomplished and able engineer in charge of the improvement of the Missouri River: —

United States Engineer's Office,
1351 Washington Avenue, St. Louis, January 31, 1881.

Dear Captain: — I have watched with much interest the development of your plan for the construction of a ship railway across the Isthmus. The project has great and obvious advantages to recommend it; and from an engineering point of view, it is, in my opinion, perfectly practicable. The various operations contemplated are constantly being performed, on a small scale at least, at all the great seaports of the world, and any difficulties which might attend their extension to the scale you propose, could, I think, be readily met by suitable mechanical devices. The construction, maintenance, and operation of the railroad are quite within the resources of our profession.

With my best wishes for your success, I am, Captain,

Yours very truly,

Chas. R. Suter,
Major of Engineers, U. S. A.

Capt. James B. Eads, Washington, D. C.

The City Engineer of Pittsburg, a gentleman who has had an extensive practical experience in engineering works, has sent the following: —

City Engineer's Office,
Pittsburg, Pa., January 31, 1881.

James B. Eads, Esq.

Dear Sir: — I heartily indorse the project of a ship railway across the "cord of the continents," in preference to a canal. My reasons are that it will not cost more than about one-third as much as a canal with locks; it will not require more than one-half of the time to construct it that will be consumed in the construction of the canal; it will cost less to maintain and operate it than a canal, and the facilities of transportation can be much more readily, cheaply, and advantageously increased on the railway than on a canal when the necessities of commerce require it, and the very "leviathans of the merchant marine" can be transported more easily and with as much safety on the railway as through the canal, and without any break of cargo,

or any danger thereto. It would extend this letter to too great a length to give figures to ratify the statement herein made, but they will substantiate it to the full; and I further state that if the profits of the "canal investment" would amount to "five per cent" those of the railway project would amount to not less than twenty per cent on the investment, and very probably more; yea, it would be a paying investment under circumstances of disastrous loss to the canal projectors; therefore, in view of all the considerations connected therewith, I have come to the conclusion above embodied.

Hoping that you may succeed in procuring the necessary encouragement and substantial aid that the importance of the project demands, so that you may be enabled to demonstrate practically the truth of the above and verify the assertions made.

I am, most respectfully, etc.,

A. Dempster, *City Engineer.*

The writer of the following letter, Mr. Max E. Schmidt, is a member of the American Society of Civil Engineers, was for several years resident engineer at the jetties, was afterwards in charge of important river improvements on the upper Mississippi, and is now engaged in the construction of one of the Mexican railways. He is an engineer of acknowledged ability and standing: —

St. Louis, Mo., March 22, 1881.

Mr. James B. Eads, C. E., Washington, D. C.

Dear Sir: — In 1718 Emanuel Swedenborg, at the age of 30, performed a "noble feat in engineering by hauling two galleys, five boats, and a sloop some fourteen miles overland." If this could be accomplished at a time when steam and hydraulic engines were unknown, why should not the present century at its close witness the conveying of vessels across the Isthmus in the manner proposed by you? I have studied the Isthmian problem with care, and am convinced that the railway is the best solution offered. The project is based upon sound, well-known mechanical principles, and I have no doubt that a realization of the scheme will lead to its frequent duplication in the future.

Very respectfully,

Max E. Schmidt, *Civil Engineer.*

The following is from the distinguished civil engineer who is now Dean of the Department of Civil Engineering in Cornell University. He was the Chief Engineer of Commodore Shufeldt's Surveying Expedition in 1872: —

DEPARTMENT OF CIVIL ENGINEERING, CORNELL UNIVERSITY,
ITHACA, N. Y., February 4, 1881.

CAPT. JAMES B. EADS.

Dear Sir: — My surroundings during the past ten years have cut me out from taking active part in the discussions upon trans-Isthmian routes; but I have never lost my great interest in this matter, nor doubted what I have put on record several times, viz.: "Tehuantepee will be open to the world earlier than any other route." This conviction is owing to the fact that I have made a thorough, disinterested, honest, and patriotic study of nearly all the bearings of this important question, and my conclusions are almost mathematically correct. When your ship railway project appeared and was ridiculed by inconsiderate engineers, I made computations which proved conclusively to my mind that the "Great Eastern" could be carried safely overland upon rails, with less strain to her timbers than in any of her sea voyages. There can be no difficulty about wheel-base enough to support a weight that has been supported in the ways of any dock; or about rails upon which to roll the weight; or power to draw it at any desirable speed; and all this, with absolute safety to the keel, ribs, and joint points of any vessel (yet built) and transported out of water. No bridge that is now in use undergoes the bendings, twistings, and shaking that any vessel is bound to withstand, upon a rough sea, without opening a seam; and yet, no one doubts the practicability of transporting a truss by rail. In fact, every railroad car is a clumsily made truss. I am well acquainted with the data obtained, and supposed to have been obtained, to within a few years, upon the subject; and I am perfectly familiar with every possible point through which a canal could be located at Tehuantepee.

I am sure it is easy to prove that all routes outside of the Gulf of Mexico will be detrimental to the most vital interests of the United States, and a source of great danger to our national stability. But the people at large have not had a fair opportunity to study this question so as to place more faith upon its merits than upon the men advocating the routes proposed. Time must take

its course to allow the specific truth of this case to survive the machinations of partisanship. But the time has now arrived for effective work and determined action; and I thank God that your brain, reputation, and sledge-hammer has been set to work to batter the Isthmus into an American highway. I can assure you, upon knowledge of every inch of the ground, that you will find no difficulty about curves, grades, or bridges. The ascent of the Atlantic slope will offer no more difficulties than the Hudson River Railroad; and on the Pacific side, either one of the three passes in the neighborhood of Tarifa or Chivela will allow of no steeper grade than 25 to 35 feet per mile to bring you down to the Pacific plains. The ground offers you 50 miles to get down in, and as much more as you may wish by following the hillside. All the bridges required will be of comparatively short spans. You will find very little anxious work on either terminal harbor, very little tentative work being required, and permanence without ulterior complications will reward almost any kind of attack. The drainage of the works, building materials (including excellent, cement-yielding, dolomitic limestone, between San Miguel and Tarifa), abundant native labor, a remarkably healthy climate, etc., will be all you may desire.

I think the estimate of tonnage upon which you base your reasons for the safety of the government in guaranteeing three per cent semi-annual dividends is quite modest, since in spite of official statistics I believe the road will handle thirty thousand tons daily very soon after its being opened.

The discussion of this subject is long, and my letter is growing likewise long.

I write to you to give you encouragement to push on this matter with all your might. I have no personal motive to subserve; my field is here for a lifetime, which I fear will be too short for my purpose. Therefore, if I have bothered you, you at least can say this is a case of disinterested boring.

If I can be of any service to you, command me, and I will be glad to furnish any data upon unpublished notes or surveys I have, and be sure you have my most sincere wishes for the happy issue of your undertaking. Very truly yours,

E. A. Fuertes.

In discussing the merits of the several Isthmian routes before the

Merchants' Exchange, in St. Louis, pending the unanimous adoption by that body of resolutions recommending the favorable consideration of the ship railway to the government, Captain Silas Bent, a gentleman who has devoted much study to the winds and currents of the ocean, and who was formerly an officer of the United States Navy, made the following remarks:—

"Mere statements of the difference in miles is a very inadequate measure of the difference in time that would be occupied by sailing-vessels in making these several passages, and when we consider that three-fourths of the ocean commerce of the world is carried in sailing-vessels, you can see what an important factor this question of *sailing-time* becomes in the solution of the problem before us.

"The northeast trade-winds which extend across the Atlantic are so broken and interrupted when they encounter the West India Islands, that they never penetrate the Caribbean Sea; but the northwest portion of them, however, do extend into the Gulf of Mexico, and often so far down as to reach well toward Tehuantepec, so that whilst in the Gulf winds are always found, yet the Caribbean Sea remains a region of almost relentless calms.

"Nor is this all; for the mountain ranges, extending the length of the Isthmus of Panama and through Central America, offer a still more formidable barrier to the passage of these winds, thus throwing them still higher into the upper regions of the atmosphere, and extending these calms far out into the Pacific Ocean, on the parallel of Panama, with lessening width, for fifteen or eighteen hundred miles to the northwest, along the coast of Central America.

"This whole region of calms, both in the Caribbean Sea and in the Pacific Ocean, is so well known to navigators that sailing-vessels always shun it, if possible, though they may have to run a thousand miles out of their way to do so.

"This absence of wind of course leaves this vast area exposed to the unmitigated heat of a torrid sun, except when relieved momentarily by harassing squalls in the dry season, and by the deluging rainfalls of the wet season. With these meteorological facts in view, let us now suppose that the Lesseps Canal at Panama, and the Eads Railway at Tehuantepec are both completed and in running order; then let us start two sailing ships of equal tonnage and equal speed from the mouth of the Mississippi, with

cargo for China, one to go by way of the Panama Canal, and the other by the way of the Tehuantepec Railway, and I venture to affirm that by the time the Panama vessel has cleared the canal and floats in the waters of the Pacific, the Tehuantepec vessel will have scaled the Isthmus and be well on to the meridian of the Sandwich Islands; and that before the former vessel can worry through the fifteen or more hundred miles of windless ocean before her, to reach the trade winds to the westward of Tehuantepec, the latter will have sped five thousand miles on her way across the Pacific, and be fully thirty days ahead of her adversary. For it is a fact worth mentioning here, that the strength of the northeast trade winds in the Pacific, as well as the maximum strength of the northern portion of the great equatorial current in that ocean, are both found on or near the parallel of latitude of Tehuantepec, the former blowing with an impelling force to the westward of ten or twelve miles an hour, and the latter with a following strength of three or four miles per hour.

"To my mind, there is no difficulty in the way that cannot be readily overcome by engineering and mechanical skill, neither in the construction of the road nor in the necessary machinery to handle and carry vessels of any size and of any weight across the easy gradients of the Tehuantepec Isthmus.

"And I further believe that such a railway can be built at half the cost and in half the time — yes, in one-third the time — that any canal can be constructed; and that while the railway, for many reasons, would be of greater practical benefit to the commerce of the world at large than a canal, it would be in that locality of immeasurably greater advantage to both the commerce and the political well-being of our own country."

SHIP RAILWAYS AND CANALS;

By Sir Edward J. Reed, K. C. B., in Reply to a Letter Addressed to Him by Rear-Admiral Daniel Ammen, U. S. N.

[*Sir Edward Reed is a member of Parliament, and was for many years Chief Constructor of the British navy. He was made a Knight Commander of the Bath, as a recognition of his eminent abilities as a naval architect. He is a Fellow of the Royal Society; Member of the Institution of Civil Engineers, and of the Institution of Mechanical Engineers, and is Vice-President of the Institution of Naval Architects. He has written several treatises on ship-building, and is, without doubt, the highest authority in the world to-day on this subject.*]

Broadway Chambers, Westminster, London,
September, 1881.

To Rear-Admiral Ammen, U. S. N.

Dear Sir: — In a former letter I explained to you that illness, &c., prevented me from replying promptly to your esteemed favour of March 15th, and I regret to say that the same causes have operated until the present time. I will now endeavour to reply with sufficient fullness to your inquiry, first thanking you for the copies which you have so kindly sent me of papers by yourself, by Mr. Menocal and by Capt. Phelps, all of which I have read with interest and profit. Your own paper and that of Mr. Menocal are full of the most instructive and valuable information upon the various Canal projects, but naturally have little or no direct bearing upon the Ship Railway proposal. In discussing that I must therefore direct my attention to the pamphlets by Capt. Phelps which are specifically addressed to it.

The suggestion to transport ships loaded with cargo from one ocean to another over a railway more than 100 miles long is one which was certain at first to excite many doubts and suspicions, both among those who do, and among those who do not, understand the construction of ships and railways.

But first impressions upon a matter of this kind are of little value, and all such, whether favourable or otherwise, may be dismissed from consideration. Let us investigate the matter closely, and in the light of existing knowledge and experience.

And in the first place I feel obliged to express surprise at the contention of Capt. Phelps that the ship-railway across the Isthmus of Tehuantepec must be adapted for transporting "the heaviest vessels used anywhere." On the contrary, the primary requirement clearly is, that the railway should be adapted to carry the vessels engaged in ordinary commerce, and more particularly such as are employed in distributing to the world the corn and other products of California and the neighbouring States. To Americans, the quick and economical interchange of products between the Eastern and Western States, by means of their own mercantile vessels, would, I think, be the primary object to attain; for this purpose it would certainly not be necessary to provide for the transport of such ships as the "City of Rome," the "Servia," and other immense vessels now building in this country expressly and solely for improving the intercourse between America and Europe. On the contrary, I should anticipate that a ship-railway across the Isthmus of Tehuantepec, which would reduce the sea communication between the East and West of the United States to the utmost possible extent, would be a great stimulant to the employment of American built vessels, of wood as well as of iron; and in so far as the wood-built sailing vessels are concerned, it is obvious that the demand for immense size would not arise. Looking to the still available resources of the United States in ship-building timber, I can understand that the ship-railway would be a very great encouragement to the continued building of this class of ships in Maine and other States. There is undoubtedly a general tendency to increase the size of iron-built steamers in many trades, and this will certainly have to be taken into account in determining the character both of the railroad and of the terminal works, but after much consideration of the subject I have satisfied myself that no present necessity exists, or is in view, for proceeding with the ship-railway upon a scale so large as to accommodate the heaviest and longest of the passenger liners now in course of construction. The trade of the world, and assuredly the American trade, would be amply provided for if pro-

vision is made for transporting ships of a maximum displacement of 6,000 tons. But even 6,000 tons displacement is a limit higher than would be needed to accommodate the vast majority of the world's merchant-vessels at present, and would provide for a large and pretty general increase in their size hereafter. I will add but two remarks in this connection: (1.) It might be wise, and would certainly be easy, to ensure the commercial success of the ship-railway across Tehuantepec by carrying, in the first instance, vessels of say 4,000 tons at most, making due provision for the subsequent increase of size and weight in such a manner as to avoid interference with the operation of the line. (2.) One of the advantages which the railway project possesses is that, if suitably designed, its capability of transport, both as to the size and as to the number of vessels transported, can be increased with facility and economy.

You will see from what I have already said that I am unable to accept the view of Capt. Phelps with respect to the weight of the ships to be carried. I regret to say that I am equally unable to accept his statement of the auxiliary weights to be carried, viz., those of the ship car and cradle. These Capt. Phelps regards as about equal to the weight of the ship and cargo. I am of opinion — after making some guiding calculations — that the weight of a car and cradle, of ample strength to carry a ship of 4,000 tons weight, need not exceed 500 tons; if to carry a ship of 6,000 tons it need not exceed 750 tons. The aggregate weight to moved, therefore should be:—

For a ship weighing, with cargo,	4,000 tons,	- - - -	4,500 tons.
" " "	6,000 "	- - - -	6,750 "

I therefore regard his estimate as enormously excessive.

I will next consider the mode of raising and transporting the ships. And I would state that although there would be great and obvious conveniences in keeping the ship always afloat during the transit, I am of opinion that this would involve much unnecessary expense, both in the construction and in the working, and that no sufficient reason exists for pursuing this plan. In so far as the lifting of the ship bodily out of the water is concerned, this process is in repeated operation at the Victoria Docks on the Thames, at Malta, at Bombay, at Sebastopol, and elsewhere; while the

process of hauling ships up out of the water upon a wheeled carriage on an inclined plane laid with rails is, as you know, a very common one. I had two such hauling-up slips under my control for some time at Hull, and the company working them have found them so convenient and profitable that they are now laying down a third for hauling up ships of 3,000 tons register and more. No engineer can doubt that either process is perfectly applicable, with increased power, to ships of larger size, although I should myself prefer the process of direct lifting, for several reasons, the chief of which is that it furnishes the readiest and best opportunities for supporting the ship upon the cradle as she leaves the water.

This brings me, of course, to the crucial questions: 1. Can ships with their cargoes on board be lifted out of the water, by hydraulic lifts or otherwise, and upon adjustable cradles, without injury? 2. If this is so, can they be with safety transported overland upon such cradles? I answer both questions affirmatively, and for the following reasons: I would lay down as a first consideration that in both cases the chief cause of injury to be guarded against is not general structural strain, but local strain resulting from unequal distribution of weights, and more especially of cargo. I may perhaps be excused for speaking with some confidence upon this question, inasmuch as it was in a paper read by me before our Royal Society in 1871, and published *in extenso* by that learned body, that the principles of strain in ships and the method of estimating the strains, now universally accepted were first laid down. I affirm that the general structural strains which are likely to be brought upon a ship by lifting and transporting her, presuming, of course, that reasonable skill and care are applied to these processes, are inferior, much inferior, to those strains to which every ocean-going ship is continually liable at sea. Indeed the only structural strain which would require to be very specially guarded against, is that which exhibits itself in, and in connection with the beam-knees of wooden ships;* and even this, with proper bilge support, would be less than the like strain which occurs at sea. The strains to be most

* Perhaps I ought to mention that all my early experience as a shipbuilder, extending over some eight or ten years, was acquired in the construction and repair of wooden-built ships. — E. J. R.

apprehended, and against which it would be necessary to make effectual and ample provision, are local strains, and chiefly those arising from heavy cargo pressing severely upon parts of the bottom, and often alternating with places of much less weight, or of none at all. But I apprehend that an engineer of the skill and eminence of Capt. Eads, with all the experience of ship-builders at his command, would not undertake the work of lifting and transporting loaded ships without making full provision, as may be readily done, for applying ample local support to every ship's bilge at every part; nor would the company who construct and operate a ship-railway, and who are responsible for the ship, be likely to fail to have the support carefully applied in every case where needed. In fact, it would be made, I should think, a ruling consideration in this enterprise to so bring the great resources of hydraulic art into play, as to give to each ship that is lifted, far better support than has ever before been provided in any docking system whatever. To accomplish this object effectually would certainly be a problem of much easier solution than many which Capt. Eads and other engineers have solved with perfect satisfaction, both in your country and in ours. Nor are we without experience to guide us in this matter. The hydraulic lift at Malta has raised numerous ships, with cargo on board, without the slightest injury of any description. From a list of such vessels furnished me by Mr. Webb, the Secretary of the Anglo-Maltese Hydraulic Dock Company, Limited, I find that ships carrying heavy cargoes have been frequently raised high and dry in this way without detriment.

In the next place, it seems to me quite certain that the appliances which would secure ample and firm support to the ship, at every part, when lifted high and dry, would almost necessarily be such as would effectually keep her upright in storms, and preserve her from any injury upon the road. I take for granted that the railroad constructed for the purpose would be of the most solid kind, and so laid as to have its double or triple sets of rails as nearly as possible in the same plane, and also that the carriages would be made with equal care in all their parts. With these precautions taken, and considering that a comparatively low speed is all that is required or contemplated, I am at a loss to see in what way danger to the ship is to arise. I will only add upon this part

of the subject, that I see no sort of necessity for having a special cradle fitted to each ship, in any other sense than that of taking care to give support to each ship, wherever necessary by hydraulics or otherwise.

There are some observations of Capt. Phelps which I am at a loss to understand. I do not, for example, know what he means by saying that the pressure of the water upon the bottom of a floating ship exerts "*equal force* upon every inch of its surface;" or by saying, "whether rolling or pitching, the support from the water is uniform at all times and at all points;" or by adding, "when waves toss the ship about it becomes a falling body received upon a water cushion, so to speak, which presses and yields everywhere in exactly the same degree; hence there is little or no strain in a well-constructed ship when the weight carried is evenly distributed, as seamen take care it shall be." With all respect I must say that these statements are in conflict with both the most elementary and most developed doctrines of science, which declare that the still water-pressures upon a ship afloat vary with and as the depth; that they are consequently different in amount at different depths; and that when a ship is tossed by the waves she is thereby subjected to great, and sometimes to enormous strains, and that these strains undergo continual fluctuations. In the Royal Society paper which I have previously adverted to, I have shown that even the light wood-built yacht of Her Majesty the Queen, the "Victoria and Albert," when lifted upon the crest of a wave of her own length (300 feet) and 20 feet high from hollow to crest, has her bending moment tending to produce "hogging" (which moment in still water is 5,080 foot tons)* increased to 16,400 tons, while in the hollow of similar waves the hogging moment disappears, and is replaced by a reverse or "sagging" moment of no less than 31,000 foot tons. In the passage of a single such half-wave under her, therefore, *i.e.*, in less than four seconds, this lightly built vessel may at any time be subjected at sea to a change of breaking strain at a given section of no less than 47,400 foot tons. Forgive me if I here quote a few sen-

* Foot tons, in this sense, measure leverage which constitutes the straining or bending moment. Thus, 5,080 foot tons means a weight of 5,080 tons acting at the end of a lever 1 foot long, or 508 tons at the end of a lever 10 feet long, or any equivalent leverage.

tences bearing upon this matter from the paper referred to: "I give these figures merely as indications of what may be expected to happen in the changes of strain in ships at sea; and they probably fall much below the truth, since no account has been taken of the effect of violent pitching motions, which must lead to still more abrupt and violent changes. I will simply add that a very convenient way of expressing the effect I have been attempting to describe, is afforded by the supposition that the ship is fixed, and that what may be termed 'waves of strain' roll through her structure. The introduction of this idea will help us to understand more clearly how *changes* in strain affect a structure; for a very small strain (considered statically), which would not affect a comparatively weak structure sensibly if it were constantly acting in one direction, will suffice to destroy a far stronger structure if its direction is continually and rapidly changed. This subject has not escaped the attention of preceding writers; and Mr. Fairbairn has made some interesting remarks upon it, at page 13 of his work on 'Iron Ship-building,' where he refers to the results of a series of experiments on the endurance of iron jointed beams when subjected to changes in the loads put upon them. He says the joints of an iron-rivetted beam sustained upwards of three million changes of *one-fourth* the weight that would break it, without any apparent injury to its ultimate powers of resistance. It broke, however, with 313,000 additional changes when loaded to *one-third* the breaking weight, evidently showing that the construction is not safe when tested with alternate changes of a load equivalent to *one-third* the weight that would break it." You will see, therefore, that it is quite impossible to assent for a moment to Capt. Phelps' opinion that a well-constructed ship undergoes "little or no strain" when waves toss the ship about. On the contrary, a ship tossed about at sea undergoes enormous strains and changes of strain, the rapid recurrence of which adds greatly to their power of injury. It may serve, perhaps, to give greater definiteness to the matter if I say that while, as I have stated, the change of breaking strain caused by waves may, in the case of the royal yacht in question, readily exceed 47,400 foot tons, the whole breaking strain amidships if she were left high and dry upon two rocks, one at the bow and the other at the stern, would only be 114,700 foot tons; so that the

breaking effect of waves passing smoothly along her amounts to $\frac{47}{114}$, which is nearly one-half the greatest breaking strain that she could possibly undergo if accident left her to ground upon a rocky coast, under the very worst conditions. I therefore differ altogether from Capt. Phelps, believing that he greatly overrates the strains to which ships properly docked and transported would be subjected, and as greatly underrates the strains to which they are undoubtedly subjected at sea.

If I may now turn to the non-nautical parts of the pamphlets by Capt. Phelps, I would say that it really appears to me that the difficulties which he apprehends concerning gradients, turn-tables, tilting-tables, sidings, and locomotives requisite for a ship-railway are mainly, and in so far as they profess to be insuperable, wholly imaginary. I will not discuss them at any length, but will trouble you with only one or two remarks upon them. Capt. Phelps' estimates that 60 locomotives would be required for use upon a gradient of 40 feet per mile. Now, in a paper recently read before the British Association at York, Sir F. J. Bramwell, one of the very ablest engineering experts in this country (who, by the way, said at the same place, that "ships upon a railway would not be exposed to half the rack and strain that they are now exposed to on the ocean"), stated that at slow speed good engines would draw 800 tons. They can in fact draw more, but let us accept these figures. Sixty engines would therefore draw 48,000 tons, or 7 times the maximum weight which, as I estimate, it is at present requisite to provide for. Instead of 60 locomotives, therefore, 9 or 10 locomotives of the ordinary type would suffice, and probably 5 or 6 would be sufficient for the large majority of the ships to be transported, extra power being, of course, applied over the short distance where the gradients are exceptional. Again, Capt. Phelps give 5 tons pressure per wheel as the limit which may be properly applied; but this is only about one-half of the pressure which is sometimes allowed for the wheels of our fast-running locomotives. Instead of 4,800 wheels being required, as he estimates, I should think that the 800 (without the 4,000), would be ample for the largest carriages to be employed on the railway.

In the pamphlet entitled "Review of the Proposed Tehuantepec Ship Railway," Capt. Phelps tabulates all the largest ships in existence and in course of construction, both mercantile and war

vessels, and correctly shows that both descriptions have obtained, in exceptional instances, displacements of about 13,500 tons. I cannot myself accept the arguments with which he follows these tables, nor does it appear to me to be necessary to do so; for while I should consider it advisable to make an Isthmus *Canal*, once for all, of sufficient capacity to give passage to the very largest ships that can be found, I should deem it perfectly unnecessary to give a *ship-railway* equal capacity in the first instance, because the railroad accommodation is itself so susceptible of extension at any time. To illustrate this, let me point out the fact, employing the table of Capt. Phelps, that although the "Tokio" may have a displacement of 9,000 tons, and the "City of Rome" is to have a displacement of 13,500, the two vessels differ in breadth by only $4\frac{1}{4}$ feet, but differ in length by 123 feet. It is manifest at once that the principal change required in passing from the smaller to the larger ship would be that of providing a carriage or cradle 100 or 120 feet longer. But the fallacy of arraying the largest ships that can anywhere be found against a plain business proposal like that of the Isthmus Ship Railway, may perhaps be best seen by observing that, as Capt. Phelps shows, while the very largest of the mercantile ships, the "City of Rome," is only $52\frac{1}{4}$ feet broad, the war-ship "Inflexible" is 75 feet in breadth; so that it would appear to be the view of Capt. Phelps that it would be improper to construct a ship-railway at Tehuantepec for commercial purposes, even if it were capable of transporting the largest mercantile ships in the world, unless you added 50 per cent to the width and cost of the permanent way necessary for them, so as to accommodate the biggest iron-clad that England has ever produced! It only needs to state the case thus in order to show the fallacy of the contention, and to indicate, as I think, that it is not by considering the cases of the very largest ships that can be found in the world that the project of Capt. Eads ought to be tested. I believe that even if this were a legitimate test the scheme would not be found to fail in a scientific sense; but clearly both the commercial value of the ship-railway, and its value to the United States as a nation, are entirely independent of these exceptional cases, and must mainly be judged of by the measure of facility which its adoption would afford to the general

commerce of the world, and to the mercantile marine of the United States in particular.

I do not think I need add to these observations, which have occurred to me on reading the pamphlets of Capt. Phelps. But in your letter to me you make specific mention of a proposal said to have been made by Capt. Eads, to allow the ends of vessels to project, if necessary, beyond the supporting cradle by 50 or 60 feet. I do not understand Capt. Eads to have made any general proposal of this kind, and I feel confident that he would confine any such proposal to the case of iron ships; it certainly would not be safe to allow such overhang in wooden vessels, but in iron vessels of large size it would, as a rule, do no harm whatever. It will follow from what I have previously said, that the bending moments due to such unsupported ends would be very small in comparison with the bending moments induced by the straining action of ocean waves. Of course it is possible that when the ship was in motion along the railway, a considerable amount of lateral vibration might be set up; but I am at a loss to understand how either the forces producing the vibration, or its amount, could well be so great as those which are often experienced in screw steamships of immense engine power when under full steam; and yet these vibrations, although sometimes distressing and almost alarming, seldom do any actual harm. If any excessive tendency to vibration should exhibit itself, which I very much doubt, it would not be difficult to check it sufficiently by mechanical appliances.

I do not feel at liberty to discuss, with my present information, the relative cost of the Nicaraguan Canal and of the ship-railway of Tehuantepec. I should require to give both projects more lengthened investigation with that object in mind. All that I do feel justified in saying is, that it seems to me that the advantage as between the Canals of Panama and Nicaragua are all on the side of the latter, from almost every point of view, while from the point of view of United State citizens the preponderance of advantage in favor of the Nicaraguan route is enormous.

As regards the comparative economy of transporting a ship's cargo by canal or railway, I am inclined to believe that the railway would prove the more economical of the two.

It was stated in evidence before a committee of the House of

Commons, by the chairman of the Great Eastern Railway Company, on the 7th March, 1878, that coals could be profitably transported by this company at the rate of $\frac{1}{4}$d per ton per mile; and this was confirmed by the locomotive superintendent of the North-Western Railway, on the 21st March, 1878. If we assume that the total distance to be hauled across the Isthmus of Tehuantepec is 150 miles, it would appear that a ship's cargo can be profitably carried for that distance, in the ship, over a first-class railway, for $0.75 per ton. I arrive at this conclusion from the following considerations: 1st, $\frac{1}{4}$d, or one-half cent, per mile gives $0.75 per 150 miles; and, 2nd, the weight of the ship and car upon which she is transported appears to bear about the same ratio to the cargo carried in the ship, when fully loaded, that the weight of a coal-car bears to the weight of coals it carries. It was also stated in evidence, on the occasion above referred to, that the weight of coal carried on one truck is $7\frac{3}{4}$ tons, and the weight of the truck $4\frac{1}{2}$ tons. The paying load is, therefore, about 58 per cent of the total; and this is about the proportion that the cargo would bear, in many ships, to the total weight of the ship, car and cargo. These facts are sufficient to show that the transport by ship-railway, over a first-class road with easy gradients, in a country where fuel is abundant and labor not excessively dear, ought to be about the same per ton per mile, for the cargo carried, as in England. If, however, we assume it to be twice as expensive, the rate would then be $1.50 per ton across the Isthmus of Tehuantepec. I am credibly informed that at this time $20 per ton is being paid for the transport of grain from California, round Cape Horn, to Liverpool.

It should be borne in mind that there are two elements in the ship-railway plan proposed by Capt. Eads which tend to greater economy than is obtained in the railway system of England: 1st, the ship-railway will be devoid of all curves; and, 2nd, the cargo transported will be handled wholly by machinery, and in vast bulk.

I am afraid, Dear Admiral Ammen, judging from some indications which I have observed in letters from your pen, that the views which I have herein expressed concerning the ship-railway will appear to you both unexpected and unsatisfactory. I shall very much regret it if this be so, because to differ with an officer

of your experience and of your manifest fair-mindedness must necessarily detract from one's own influence. At the same time I find myself wholly unable to believe that there are many ships at sea which could not, with proper appliances and the needful care, be lifted, fully loaded, from the water, and transported upon rails; and if ships could not be thus employed as railway cars for their own goods, I should think it time to deal with the matter the other way about, and make large cargo carriages which could take the sea, and steam and sail efficiently there. I have, therefore, no words but those of encouragement for a ship-railway, regarded from my point of view as a ship-builder, accustomed for a life-time (which is getting now to be a long one) to the designing, building, repairing and docking of both wood and iron ships; and while wishing no harm to the Nicaraguan Canal scheme, and not having anything to say against it, I trust the ship-railway scheme may also, for the credit alike of engineering science and of commerce, be hereafter discussed by others with that dispassionateness with which, I am confident, it will always be treated by you.

Will you allow me to add an expression of the very great sorrow and pain which are everywhere felt in this country on account of the attack made upon your President, also of our heartfelt sympathy with him in his sufferings, and of our admiration at the heroism displayed by him throughout them. His name and his noble endurance are upon every tongue here.

I have the honour to be, Dear Admiral Ammen,

Yours, very truly,

E. J. REED.